

Smart Industrial Product Counting and Sorting Machine

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Abstract- In modern industrial automation, accuracy, speed, and reliability in production line monitoring are critical factors for improving productivity and minimizing human intervention. The Smart Industrial Product Counting and Sorting System is designed to automate the process of counting products and separating defective items using embedded systems and sensor-based technology. This project integrates mechanical and electronic subsystems to create an efficient, low-cost, and user-friendly industrial solution. In conclusion, the Smart Industrial Product Counting and Sorting System provides a compact, cost-effective, and efficient solution for modern production lines, aligning with the growing demand for automation in industries.

Keywords: Arduino, Servo motor, IR Sensor, Conveyor belt, Object Detection, etc.

I. INTRODUCTION

INTRODUCTION TO INDUSTRIAL AUTOMATION

Industrial automation plays a significant role in modern manufacturing and production systems. Industries continuously aim to increase productivity, improve product quality, and reduce operational costs. Traditional manual monitoring of production lines often leads to errors, inefficiency, and higher labor requirements. As industries grow, the need for automated systems that can monitor, count, and sort products becomes essential.

Automation technologies such as microcontrollers, sensors, and electromechanical devices have enabled industries to implement intelligent systems capable of performing tasks that previously required human supervision. Among these tasks, product counting and sorting are very important operations in packaging units, manufacturing plants, food processing industries, pharmaceutical industries, and logistics sectors.

Manual product counting is time-consuming and prone to human error, especially when dealing with high-speed production lines. Similarly, detecting defective or faulty

products manually can slow down the production process and reduce efficiency. Therefore, automated product counting and sorting systems are widely adopted in modern industries to improve accuracy and speed.

The **Smart Industrial Product Counting and Sorting System** is designed to automatically detect products moving on a conveyor belt, count them accurately, and separate faulty items using sensor-based technology and microcontroller control. The system uses infrared sensors, a microcontroller, and a servo-based sorting mechanism to perform these operations efficiently.

OVERVIEW OF THE PROPOSED SYSTEM

The proposed system is a smart automation model that integrates mechanical components with electronic control circuits. The system mainly consists of a conveyor belt mechanism, sensors, a microcontroller unit, and output devices such as a display and sorting actuator.

Products move along the conveyor belt driven by a **10 RPM DC gear motor**. As the products travel through the conveyor path, they pass in front of **IR sensors** that detect their presence. The first sensor counts each product, while the second sensor checks for faulty products.

The **Arduino Nano** microcontroller processes signals from these sensors. When a product is detected by the first IR sensor, the system increments the total product count and displays it on a **16x2 LCD display** using an **I2C communication module**. This allows real-time monitoring of the number of items passing through the system.

If the second IR sensor detects a faulty product, the system activates a **SG90 servo motor**, which rotates to push the defective item off the conveyor belt into a separate collection area. This automatic sorting mechanism prevents defective products from reaching the final packaging stage.

The system also includes a **buzzer** that provides audible alerts during product detection or faulty product

identification. A **push button** is used to reset the counting system, and **slide switches** are used to control power and system operation.

The power supply for the system is provided by a **12V 1A adapter**, which is converted to the required voltage levels using a **DC buck converter** to safely power the Arduino Nano and other electronic components.

NEED FOR THE SYSTEM

In many small and medium-scale industries, manual product counting and sorting are still practiced. This method has several disadvantages, including human error, slow processing speed, and increased labor costs. As production demand increases, these limitations can significantly affect efficiency.

An automated counting and sorting system addresses these issues by ensuring accurate product tracking and quick detection of faulty items. By using sensors and microcontrollers, the system can operate continuously without fatigue or mistakes. It also reduces the dependency on manual labor and improves overall production efficiency.

Another important aspect is quality control. Faulty products that pass through production lines without detection can lead to customer dissatisfaction and financial losses. The proposed system helps identify and remove defective items early in the process, improving product reliability and maintaining industry standards.

Thus, implementing a smart product counting and sorting system helps industries achieve higher productivity, better quality assurance, and reduced operational costs.

APPLICATIONS OF THE SYSTEM

The Smart Industrial Product Counting and Sorting System can be applied in various industrial sectors where automated product monitoring is required. Some important applications include:

- Packaging industries for counting packed items.
- Food processing industries for sorting food packets or containers.
- Pharmaceutical industries for counting medicine bottles or blister packs.
- Electronic component manufacturing for sorting defective components.
- Warehouse and logistics systems for inventory monitoring.

- Small-scale manufacturing industries for automated production line management.

Because of its modular design and simple architecture, the system can be easily modified and scaled for different industrial applications.

ADVANTAGES OF THE SYSTEM

The proposed system offers several advantages over traditional manual systems. It ensures accurate counting of products and efficient detection of faulty items. The automation reduces human involvement and minimizes errors. The system also provides real-time monitoring through an LCD display, making it easier for operators to track production progress.

Another important advantage is cost-effectiveness. The use of affordable components such as Arduino Nano, IR sensors, and a servo motor makes the system suitable for small and medium industries. Additionally, the system is easy to install, operate, and maintain.

SCOPE OF THE PROJECT

The scope of this project is to develop a compact and intelligent automation model capable of performing product counting and sorting operations on a conveyor system. The project demonstrates the integration of mechanical and electronic systems to achieve industrial automation.

Future improvements may include adding wireless monitoring using IoT modules, implementing machine vision for advanced defect detection, and increasing conveyor speed for large-scale industrial applications.

This project provides a practical foundation for understanding sensor-based automation systems and their role in modern industrial environments.

II. LITREATURE REVIEW

1] Introduction to Literature Review

A literature review is an essential part of any engineering project, as it provides an understanding of existing technologies, methodologies, and research developments related to the proposed system. In the field of industrial automation, several researchers have worked on automated product counting and sorting systems using microcontrollers, sensors, and conveyor mechanisms.

This chapter reviews various research papers, journals, and previous works related to conveyor-based counting and sorting systems. It helps identify the strengths and limitations of existing systems and provides a foundation for developing an improved and cost-effective solution.

2] Review of Existing Systems

1. IR Sensor-Based Counting and Sorting Systems

A recent study presented an automated conveyor system using **IR sensors and Arduino controllers** for object detection and sorting. The system demonstrated high accuracy in counting and sorting operations with minimal delay. It significantly reduced human intervention and improved production efficiency.

The research highlighted that IR sensors are highly effective for detecting object presence and size, making them suitable for real-time industrial applications. The integration of microcontrollers ensures reliable and flexible system control.

2. Arduino-Based Conveyor Tracking Systems

Another research work focused on an **automatic conveyor tracking system using Arduino and sensors like photodiodes and ultrasonic sensors**. The study emphasized the importance of automated material handling in achieving high production rates.

The system demonstrated that automated conveyors can efficiently transport products while reducing manual labor. However, the use of multiple sensors increases system complexity and cost.

3. Ultrasonic Sensor-Based Sorting Systems

A study presented an automatic sorting system that uses an **ultrasonic sensor to measure object height** and sort products accordingly. The system uses a conveyor belt, servo motor, and Arduino controller to perform sorting and counting operations.

This approach provides accurate classification based on size, but it is slightly more complex compared to simple IR-based systems. It also requires calibration for different object dimensions.

4. Weight and Advanced Sensor-Based Sorting Systems

Some research has focused on sorting objects based on **weight, color, or material properties** using advanced sensors such as load cells, laser sensors, and capacitive sensors. These systems provide high precision and can differentiate objects more accurately.

However, such systems are more expensive and require complex circuitry and programming, making them less suitable for small-scale or low-cost industrial applications.

5. Bottle and Object Sorting Using Multiple Parameters

A study on bottle sorting machines used **IR sensors, color sensors, and servo motors** to sort objects based on multiple parameters such as height and color. The system achieved efficient sorting with a capacity of around 360– 370 items per hour.

This demonstrates that combining multiple sensors improves sorting accuracy but increases system complexity and cost.

6. Arduino-Based Counting Systems in Production Lines

Another research focused on using **IR sensors and LCD display with Arduino** for counting products in a production system. The system provided real-time monitoring of product count and reduced human error significantly.

This confirms that IR-based counting systems are simple, reliable, and widely applicable in industrial environments.

7. Conveyor-Based Sorting Using Embedded Systems

Earlier studies have shown that **Arduino-based conveyor systems using IR sensors** can efficiently sort objects based on height or presence. These systems are widely used in small and medium industries due to their low cost and ease of implementation.

They also highlight that automation reduces sorting time and improves productivity.

3] Research Gaps Identified

From the literature review, the following gaps have been identified:

- Many systems are **complex and costly**, making them unsuitable for small industries.

- Advanced systems require **high computational power** and complex programming.
- Some systems lack **real-time display and user interaction features**.
- Limited focus on **low-cost, compact, and easy-to-install solutions**.
- Few systems integrate **both counting and sorting in a single unit** efficiently.

4] Proposed System Contribution

The proposed **Smart Industrial Product Counting and Sorting System** aims to overcome the limitations identified in existing systems by:

- Using **low-cost components** such as Arduino Nano, IR sensors, and servo motor.
- Providing **both counting and sorting functions in a single system**.
- Implementing a **simple yet effective design** suitable for small-scale industries.
- Offering **real-time monitoring using LCD display**.
- Ensuring **easy installation and maintenance**.
- Reducing system complexity while maintaining efficiency.

III. METHODOLOGY

1. Introduction

The methodology of the Smart Industrial Product Counting and Sorting System defines the systematic approach used to design, develop, and implement the project. It includes the working principle, system architecture, hardware integration, and software logic used to achieve automatic counting and sorting of products on a conveyor belt.

This chapter explains how different components such as sensors, microcontroller, conveyor mechanism, and actuators interact to perform the desired operations efficiently and accurately.

2. System Architecture

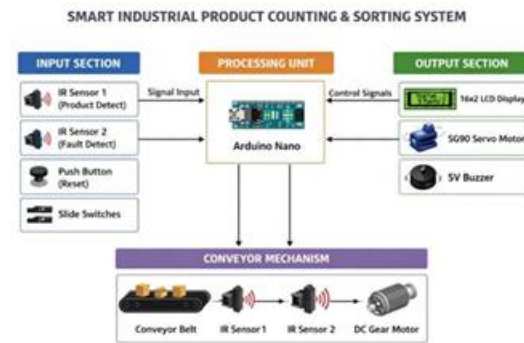


Figure 1 System Architecture

The system is divided into three major sections:

1. Input Section

- IR Sensor 1 (Product Detection)
- IR Sensor 2 (Fault Detection)
- Push Button (Reset)
- Slide Switches (Power and Control)

2. Processing Section

- Arduino Nano Microcontroller

3. Output Section

- SG90 Servo Motor (Sorting Mechanism)
- 16x2 LCD Display with I2C
- 5V Buzzer (Alert System)

4. Mechanical Section

- Conveyor Belt (2-inch belt)
- 10 RPM DC Gear Motor
- Grooved Wheels and L-Clamps
- Base Sheet Structure

The system follows a **real-time embedded control architecture**, where sensor inputs are continuously monitored and processed to generate corresponding outputs.

Working Principle

The system operates on the principle of **object detection using infrared sensors and automated actuation using a servo motor**.

1. Products are placed on the conveyor belt.
2. The DC gear motor rotates the belt at a constant speed.

3. As each product passes through the first IR sensor:
 - The sensor detects the object.
 - A signal is sent to the Arduino Nano.
 - The total product count is incremented.
4. The product then moves toward the second IR sensor:
 - If the product is identified as faulty (based on placement or absence conditions), the sensor triggers.
 - The Arduino increments the faulty count.
5. The servo motor rotates to remove the faulty product from the conveyor.
6. The LCD display shows:
 - Total product count
 - Faulty product count
7. The buzzer provides audible alerts for:
 - Product detection
 - Fault detection
 - System reset

Flow of Operation

The system follows a sequential and loop-based execution process:

1. **System Initialization**
 - Power supply is turned ON using the slide switch.
 - Arduino initializes all components.
 - LCD displays startup message.
2. **Continuous Monitoring**
 - IR sensors continuously scan for object presence.
3. **Product Counting**
 - When IR Sensor 1 detects a product:
 - Count is incremented.
 - Buzzer beeps once.
4. **Fault Detection and Sorting**
 - When IR Sensor 2 detects a faulty product:
 - Faulty count is incremented.
 - Servo motor rotates to remove the product.
 - Buzzer beeps twice.
5. **Reset Operation**
 - When push button is pressed:
 - All counts reset to zero.
 - LCD updates accordingly.
 - Buzzer beeps three times.
6. **Display Update**
 - LCD continuously shows updated counts.

Hardware Methodology

Power Supply System



Figure 2 Power Supply

The system uses a **12V 1A adapter** as the main power source. A **DC buck converter** is used to step down the voltage to 5V required for the Arduino Nano, sensors, LCD, and servo motor. This ensures stable and regulated power supply.

Sensor Integration



Figure 3 IR sensors

Two IR sensors are used:

- **IR Sensor 1 (Counting Sensor)** Positioned at the beginning of the conveyor to detect each product.
- **IR Sensor 2 (Fault Detection Sensor)** Positioned near the sorting area to identify faulty products.

The sensors work on **infrared reflection principle**, where the presence of an object interrupts or reflects IR rays, generating a digital signal.

Conveyor Mechanism

The conveyor system is a key mechanical part of the project:

- Driven by a **10 RPM DC gear motor** for controlled motion.



Figure 4 10 RPM DC gear motor

- Uses **black grooved wheels** to guide the belt.



Figure 5 Pulley wheels

- **2-inch belt** carries the products.



Figure 6 belt

- **L-clamps** provide structural support.



Figure 7 L-clamps

- A **dummy motor** ensures alignment and balance.



Figure 8 dummy motor

The slow speed ensures accurate detection and sorting.

Sorting Mechanism



Figure 9 SG90 servo motor

The sorting mechanism uses an **SG90 servo motor**:

- Normally positioned at 0°.
- Rotates to 180° when a faulty product is detected.
- Pushes the faulty product off the conveyor.
- Returns to original position after operation.

This mechanism ensures quick and precise removal of defective items.

Display System



Figure 10 16x2 LCD display

A **16x2 LCD display with I2C module** is used:

- Displays total and faulty counts.
- Reduces wiring using I2C communication.
- Provides real-time monitoring.

Alert System



Figure 11 5V buzzer

A **5V buzzer** is used for audio feedback:

- 1 beep → Product detected
- 2 beeps → Faulty product detected
- 3 beeps → System reset

Software Methodology

The system is programmed using the Arduino IDE. The logic is implemented using embedded C programming.

Sensor Logic (Debouncing / State Control)

The code uses boolean variables:

- productState
- faultyState

These prevent multiple counts for a single object by ensuring counting occurs only once per detection cycle.

Counting Algorithm

- When IR sensor output becomes LOW:
 1. Increment counter
 2. Trigger buzzer
- When sensor returns HIGH:
 1. Reset detection state

Fault Detection Algorithm

- Detect faulty product using second IR sensor
- Increment faulty count
- Activate servo motor
- Generate buzzer alert

Servo Control Logic

- Rotate servo to 180°
- Wait for product removal
- Return to 0° position

Display Algorithm

Continuously update LCD with:

- Total count
- Faulty count

Reset Logic

- Detect push button press

- Reset counters
- Clear LCD
- Provide buzzer feedback

Algorithm of the System

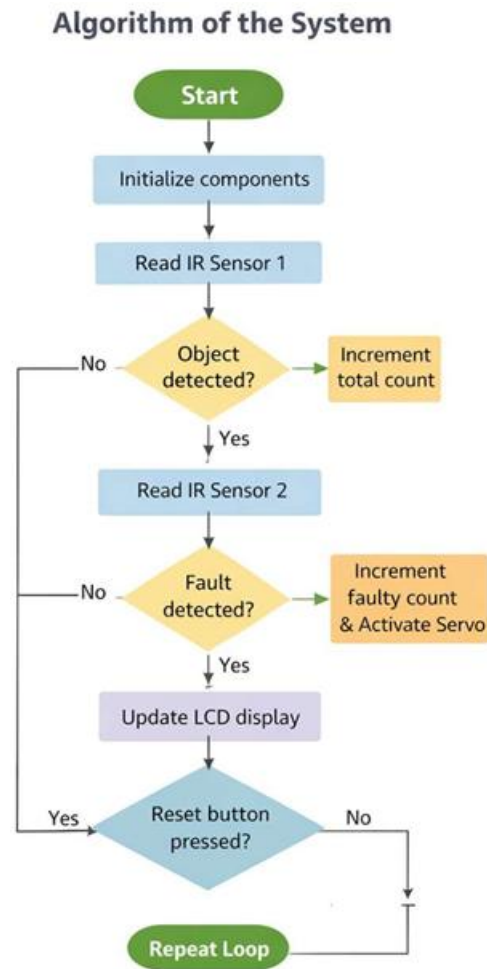


Figure 12 Algorithm of the System

Advantages of the Methodology

- Simple and efficient design
- Real-time operation
- Low-cost implementation
- Accurate counting using state logic
- Automatic sorting reduces human effort

Limitations of the Methodology

- Limited to basic fault detection (no advanced parameters like color/weight)
- Suitable for low-speed conveyors
- IR sensors may be affected by ambient light

IV. SOFTWARE REQUIREMENT

Introduction

Software plays a very important role in the working of the Smart Industrial Product Counting and Sorting System. It acts as the brain of the system, controlling all operations such as reading sensor inputs, counting products, detecting faulty items, operating the servo motor, updating the display, and generating alerts.

In this project, simple and efficient software is developed using the Arduino platform. The program is written in Embedded C language using Arduino IDE, which is easy to understand and widely used for microcontroller-based projects.

Software Used

Arduino IDE

The main software used in this project is the **Arduino Integrated Development Environment (IDE)**.

Features of Arduino IDE:

- Easy to use for beginners
- Supports C/C++ programming
- Built-in functions for hardware control
- Simple code uploading to Arduino Nano
- Large community support The Arduino IDE is used to:
 - Write the program (code)
 - Compile the code
 - Upload the code into the Arduino Nano

Programming Language

The programming language used is **Embedded C**, which is specially designed for microcontroller-based systems.

Why Embedded C is used:

- Simple and efficient
- Direct control over hardware
- Fast execution
- Suitable for real-time systems

4. Libraries Used

To make programming easier, some pre-defined libraries are used:

1. Wire.h

- Used for I2C communication
- Helps Arduino communicate with LCD

2. LiquidCrystal_I2C.h

- Used to control 16×2 LCD display
- Reduces wiring using I2C module

2. Servo.h

- Used to control SG90 servo motor
- Allows easy rotation control (0° to 180°)

Software Functions of the System

The software is designed to perform the following tasks:

- Read signals from IR sensors
- Count total number of products
- Detect faulty products
- Control servo motor for sorting
- Display data on LCD
- Generate buzzer alerts
- Reset system when button is pressed

Program Structure

The Arduino program is divided into three main parts:

1. Header Section

This section includes libraries and defines pins.

Example:

- LCD initialization
- Servo setup
- Pin definitions

2. Setup Function

```
void setup()
```

This function runs only once when the system is powered ON.

Functions performed:

- Set pin modes (input/output)
- Initialize LCD display
- Attach servo motor

- Display startup message

3. Loop Function

```
void loop()
```

This function runs continuously.

Functions performed:

- Detect product using IR sensor
- Count products
- Detect faulty items
- Operate servo motor
- Update LCD display
- Check reset button

Working of the Software

Product Detection Logic

- When a product passes IR Sensor 1:
 1. Arduino reads LOW signal
 2. Total count increases
 3. Buzzer beeps once
- A variable is used to prevent multiple counting for the same object.

Fault Detection Logic

- When a faulty product is detected by IR Sensor 2:
 1. Faulty count increases
 2. Servo motor rotates
 3. Buzzer beeps twice

Servo Motor Control

1. Servo rotates to **180°** to remove faulty product
2. Returns to **0°** after delay

LCD Display Logic

The LCD continuously shows:

1. Total product count
2. Faulty product count Example:
Total: 10
Faulty: 2

Reset Button Logic

- When push button is pressed:

1. All counts become zero
2. LCD clears
3. Buzzer beeps three times

Buzzer Function

Different beep patterns indicate different actions:

- 1 beep → Product detected
- 2 beeps → Faulty product
- 3 beeps → Reset

Advantages of Software Design

- Simple and easy to understand
- Real-time operation
- Accurate counting using logic control
- Less memory usage
- Fast processing

Limitations of Software

- No advanced fault detection (like color or weight)
- Fixed logic (cannot detect complex defects)
- Limited to small-scale applications

V. ADVANTAGES, DISADVANTAGES AND APPLICATIONS

Introduction

This chapter explains the benefits, limitations, and practical uses of the Smart Industrial Product Counting and Sorting System. Every engineering system has its strengths and weaknesses, and understanding them helps in improving the system and applying it effectively in real-world situations.

The proposed system is designed to automate product counting and sorting using simple and cost-effective components, making it suitable for small and medium-scale industries.

Advantages of the System

1. Automation of Industrial Process

The system automatically counts and sorts products without human involvement. This reduces manual work and increases efficiency in production lines.

2. Accurate Product Counting

Using IR sensors and programmed logic ensures accurate counting of products. The use of state variables avoids multiple counting of the same object.

3. Automatic Fault Detection and Sorting

Faulty products are automatically detected and removed using a servo motor. This improves product quality and

reduces the chances of defective items reaching customers.

4. Cost-Effective System

The system uses low-cost components such as Arduino Nano, IR sensors, and a servo motor. This makes it affordable for small-scale industries and educational purposes.

5. Real-Time Monitoring

The 16×2 LCD display shows live updates of:

- Total product count
- Faulty product count

This helps operators monitor the system easily.

6. Simple Design and Easy Operation

The system is easy to understand, install, and operate. It does not require highly skilled labor, making it user-friendly.

7. Low Power Consumption

The system operates on low voltage (5V/12V), making it energy-efficient and safe.

8. Compact and Portable

Due to its small size and simple structure, the system can be easily moved and installed in different locations.

9. Reduced Human Error

Automation eliminates mistakes caused by manual counting and sorting, ensuring reliable results.

10. Easy Maintenance

The system uses simple hardware components, making troubleshooting and maintenance easy.

Disadvantages of the System

1. Limited Fault Detection Capability

The system detects faulty products only based on IR sensing (presence/absence or placement). It cannot detect:

- Color defects
- Weight variations
- Internal damage

2. Not Suitable for High-Speed Industries

Since the conveyor runs at low speed (10 RPM), the system is suitable only for small-scale or slow production lines.

3. Sensitivity to Environmental Conditions

IR sensors may be affected by:

- Strong ambient light
- Dust or dirt
- Reflective surfaces This can reduce accuracy.

4. Limited Scalability

The system is designed for basic applications. Expanding it for large industries requires additional sensors and complex programming.

5. Mechanical Wear and Tear

Moving parts such as the conveyor belt, motor, and servo motor may wear out over time and require maintenance.

6. No Data Storage or Remote Monitoring

The system does not store data or provide remote access. All monitoring is done manually via LCD.

7. Fixed Programming Logic

The system operates on predefined conditions and cannot adapt automatically to changing industrial requirements.

Applications of the System

The Smart Industrial Product Counting and Sorting System can be used in many industries where automatic monitoring and sorting are required.

1. Packaging Industries

- Counting packaged items like boxes, bottles, or containers
- Sorting defective packages

2. Food Processing Industries

- Sorting food packets or items
- Removing damaged or improperly packed products

3. Pharmaceutical Industries

- Counting medicine bottles or tablets
- Removing defective or missing items

4. Manufacturing Industries

- Monitoring production lines
- Sorting defective components

5. Electronics Industry

- Sorting electronic components
- Detecting missing or misplaced parts

6. Warehouse and Logistics

- Counting items for inventory management
- Sorting packages based on condition

7. Small-Scale Industries

- Ideal for low-cost automation
- Useful in small production units

8. Educational Projects

- Used for learning automation and embedded systems
- Demonstrates working of sensors and microcontrollers

VI. RESULT CONCLUSION & FUTURE SCOPE

Result

The Smart Industrial Product Counting and Sorting System was successfully designed and implemented. The system was tested under different working conditions to check its performance, accuracy, and reliability.

During operation, the conveyor belt moved products smoothly using the 10 RPM DC gear motor. The first IR sensor was able to detect each product passing on the conveyor accurately, and the total count was updated correctly on the LCD display. The second IR sensor successfully detected faulty products based on the defined condition, and the system responded immediately.

Whenever a faulty product was detected, the servo motor rotated properly and removed the defective item from the conveyor path. The system also generated appropriate buzzer alerts for different operations such as product detection, faulty detection, and reset action.

The LCD display continuously showed real-time values of total products and faulty products, which made monitoring easy. The reset button function also worked effectively, allowing the user to clear the count and restart the process.

Overall, the system performed as expected with:

- Accurate product counting
- Proper detection of faulty items
- Smooth operation of the conveyor mechanism
- Reliable sorting using the servo motor
- Clear real-time display output

The project demonstrates that a simple and low-cost system can be used effectively for industrial automation tasks.

Conclusion

The Smart Industrial Product Counting and Sorting System provides an efficient and economical solution for automating basic industrial processes. The project successfully integrates mechanical components, sensors, and a microcontroller to perform automatic counting and sorting of products.

The use of Arduino Nano makes the system flexible and easy to program. IR sensors provide a simple method for detecting objects, while the servo motor enables automatic removal of faulty products. The LCD display enhances usability by showing real-time data, and the buzzer provides immediate feedback to the user.

This system reduces human effort, minimizes errors, and improves productivity. It is especially suitable for small and medium-scale industries where cost and simplicity are important factors.

Although the system is basic, it clearly demonstrates the concept of industrial automation and provides a strong foundation for further development. The project also helps in understanding how hardware and software work together in real-time systems.

Future Scope

The system can be improved and upgraded in many ways to make it more advanced and suitable for large-scale industrial applications.

In the future, advanced sensors can be added to detect more types of defects such as color, size, and weight. For example, color sensors or cameras can be used for better quality inspection. A load cell can be added to measure the weight of products for more accurate sorting.

The system can also be integrated with IoT technology, allowing remote monitoring and control through mobile applications or web interfaces. This would help industries track production data in real time from anywhere.

Another improvement can be increasing the speed of the conveyor system and using more powerful motors to handle large-scale production lines. The sorting mechanism can also be enhanced by using multiple actuators to separate products into different categories.

Data logging features can be added to store production data for analysis and record keeping. This will help industries improve efficiency and make better decisions.

Artificial intelligence and machine learning techniques can also be implemented for smart defect detection and predictive maintenance.

In conclusion, the project has a wide scope for future development and can be transformed into a fully automated and intelligent industrial system with the use of modern technologies.

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